

The distribution of the Southern Brown Bandicoot *Isoodon obesulus* in south central Victoria

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Abstract

The Southern Brown Bandicoot *Isoodon obesulus* has declined dramatically in both range and abundance since European Settlement. The species' distribution is largely determined by the availability of the dense, heathy vegetation that formed on the sandy coastal plains of south-eastern Australia. One of the five major areas of habitat in Victoria occurred in the Port Phillip-Western Port-West Gippsland region of Victoria. This 'south central' region is one of the most populated and developed regions in Australia, and habitat suitable for Southern Brown Bandicoots has become rare, highly fragmented and influenced by a range of potentially threatening processes. We looked at the historic and current distribution of Southern Brown Bandicoots in the south central region to identify options for conservation management of the species. We found evidence that populations in the Greater Melbourne area, including the Mornington Peninsula, had declined substantially in recent decades. The species is now uncommon in administratively secure conservation reserves in the region apart from the Royal Botanic Gardens Cranbourne, where recent management initiatives appear to have been effective in controlling some known threats. Surprisingly, an extensive population also persists on predominantly agricultural and utility land north of Western Port Bay, around the former 'Great' (Koo-wee-rup) Swamp where they live close to humans, livestock and domestic pets. This population faces a number of immediate threats, yet may be crucial to the long term viability of the species in the south central region. Effective management of the Koo-wee-rup population will require innovative measures to mitigate threats across a range of land uses and tenures. (*The Victorian Naturalist* 125 (5), 2008, 128-139).

Introduction

The Southern Brown Bandicoot *Isoodon obesulus* is a small terrestrial marsupial that was reportedly common and widespread at the time Europeans settled in south-eastern Australia (Gould 1845; Krefft 1865, both cited in Lunney and Leary 1988). Although the species has been recorded at a variety of locations from the central coast of NSW to the Mt Lofty Ranges in South Australia, the majority of records come from sites within 50 km of the Victorian coastline (Opie *et al.* 1990; Menkhorst and Seebeck 1995). In both NSW and South Australia the range of the species has contracted dramatically and it now appears to be restricted to just a few isolated regions in each state (Department of Environment and Conservation 2005; South Australian Department of Environment and Heritage 2005). The taxon is currently listed as endangered under the federal *Environment Protection and Biodiversity Conservation (EPBC) Act* 1999. It is also listed as endangered in New South Wales (*Threatened Species Conservation Act* 1995) and as vul-

nerable in South Australia (*National Parks and Wildlife Service Act* 1972). Because of the perceived vulnerability of the remaining populations, draft recovery plans have recently been developed for the species, covering its entire mainland distribution (Department of Environment and Conservation 2005; South Australian Department of Environment and Heritage 2005). However, despite evidence of ongoing decline throughout its range, and uncertainty about the current status of known populations, the species has been considered by some authorities to be relatively secure in Victoria (Scientific Advisory Committee Flora and Fauna Guarantee 1991; Menkhorst and Seebeck 1995a; DSE 2007).

Southern Brown Bandicoots have a disjunct distribution across southern Victoria (Fig.1). Most records are clustered within parts of the East Gippsland Lowland, Gippsland Plain (Western section), Otway Plain (Anglesea section), Warrnambool Plain (Port Campbell section), Greater

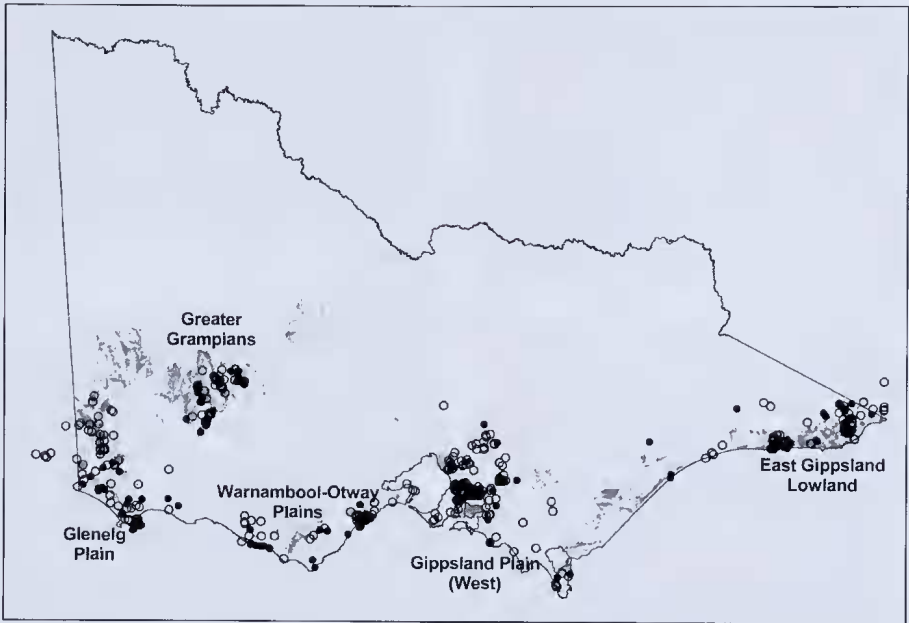


Fig. 1. Distribution of the Southern Brown Bandicoot in Victoria. Open circles indicate records from the Atlas of Victorian Wildlife before 1991; filled circles indicate records from 1991 to 2007. Grey areas represent historic extent of Heathy Woodland, Sand Heathland, Sand Heathland/Wet Heathland Mosaic and Banksia Woodland EVCs derived from pre-1750 vegetation maps (DSE 2006).

Grampians and Glenelg Plain Bioregions (NRE 1997). The species is also known from Wilson's Promontory and the Yarra Ranges, with scattered records elsewhere in the state. Records typically come from sites that support heathlands, heathy woodlands and forests, sedgeland or shrublands that occur on sandy, well-drained soils (Opie *et al.* 1990; Menkhurst and Seebeck 1995; Fig.1). The species has also occasionally been recorded further inland in riparian woodlands, scrubs and grasslands (Menkhurst and Seebeck 1995a). In East Gippsland bandicoots most commonly occur in Ecological Vegetation Classes (EVCs) such as Lowland Forest or Banksia Woodland that are analogous to the heathy woodlands found elsewhere in the state. In several regions, large areas of potential habitat occur within major National Parks or other secure reserves, providing some confidence in the long-term viability of the species at a State level (Menkhurst and Seebeck 1990, 1995a). However, within the Gippsland Plains Bioregion, particularly the western section spanning the region between Port Phillip Bay and Cape Liptrap,

there are few if any large continuous tracts of habitat capable of supporting large populations of Southern Brown Bandicoots (NRE 1997). This area, subsequently referred to as south central Victoria, is the most populated region of Victoria; and extensive land clearance for agriculture and urban development has seen the loss or fragmentation of most areas of habitat suitable for Southern Brown Bandicoots. The remaining patches of indigenous vegetation probably only support small, isolated populations that are potentially highly vulnerable to extinction (e.g. Reed 2004). As a consequence, Southern Brown Bandicoot populations may be at greater risk of decline in south central Victoria than in other regions of Victoria.

Bandicoots were reportedly '...common throughout the whole bush' around Melbourne and the Mornington Peninsula in the 1800s (Wheelwright 1862). By the later half of the 20th century, wildlife experts were warning of the apparently inevitable and ongoing decline of Southern Brown Bandicoots in the region (e.g. Dixon 1966; Seebeck 1977). These pes-

simistic predictions were due in part to recognition of the likely impacts of suburban expansion on remnant bandicoot populations. Urbanisation often leads to dramatic loss and modification of habitat and results in high densities of introduced predators, high road mortality, changed fire regimes, habitat fragmentation and subsequent isolation of populations, all of which are identified as major threats to the species (Department of Environment and Conservation 2005).

Southern Brown Bandicoots were known to persist at some sites in the Greater Melbourne region until relatively recently (Atlas of Victorian Wildlife; Brereton *et al.* 2004; Hans Brunner pers. comm.; Jeff Smith pers. comm.) but anecdotal evidence indicates that most, if not all, of these populations have now disappeared. This mirrors a familiar pattern of population isolation, decline and local extinction that has occurred throughout the species' range in south-eastern Australia (Paull 1995; Department of Environment and Conservation 2005). There is a clear risk that populations that remain in the south central region of Victoria will also continue to decline unless threats are effectively managed.

Despite its wide geographic distribution, the factors that determine the suitability of habitat and the causes of decline of Southern Brown Bandicoot populations are poorly understood (Opie *et al.* 1990; Braithwaite 1995). The species is now curiously rare in many less developed regions, including some with extensive areas of potentially suitable habitat secured within conservation reserves (Opie *et al.* 1990; Menkhorst and Seebeck 1995; Paull 1995; TSSC 2001; Coates and Wright 2003; Robley and Wright 2003; Andrew Murray pers. comm.). Paradoxically, Southern Brown Bandicoot populations occasionally persist in highly modified landscapes near urban settlements where they presumably face high levels of threat (Department of Environment and Conservation 2005; South Australian Department of Environment and Heritage 2005; pers. obs). Given the somewhat enigmatic nature of bandicoot distribution it is difficult to predict the location of bandicoot populations in the fragmented

landscape remaining in south central Victoria. However, the ongoing decline and potential vulnerability of populations demands an assessment of the current status of the species in the region. This paper attempts to increase knowledge pertaining to the current distribution and status of Southern Brown Bandicoot in south central Victoria and to inform management of the remaining populations.

Methods

South Central Study Area

The study area comprises the western section of the Gippsland Plains Bioregion (NRE 1997, Fig. 2), extending east from the city of Melbourne to Drouin and south to Cape Liptrap. The area includes the eastern and south-eastern Suburbs of Melbourne, the Mornington Peninsula and Western port Bay (including French and Phillip Islands) and extends along the Bass Coast from San Remo to Walkerville. Although some evidence suggests that Southern Brown Bandicoots may once have occurred more extensively in the eastern section of the Gippsland Plains Bioregion (Bilney *et al.* 2006), this area was excluded from the study because there were few modern records of the species (Menkhorst and Seebeck 1995a; Atlas of Victorian Wildlife). For the purposes of discussion we have arbitrarily divided the study area into seven main geographic zones. These zones are shown on Fig. 2 and comprise: (1) the south-eastern suburbs of Melbourne; (2) northern Mornington Peninsula; (3) southern Mornington Peninsula; (4) Western Port Bay area; (5) Koo Wee Rup Swamp; (6) foothills (outer swamp) and (7) Bass Coast.

Location Records

Records of Southern Brown Bandicoots within Victoria up to 2007 were extracted from the Atlas of Victorian Wildlife database by officers within the Biodiversity Branch, Department of Sustainability and Environment (DSE), Victoria. Atlas of Victorian Wildlife data is made available within DSE via the Department's Corporate Geospatial Data Library. All records classed as either 'confirmed' (identified by an experienced observer) or 'acceptable' (little or no reason to doubt

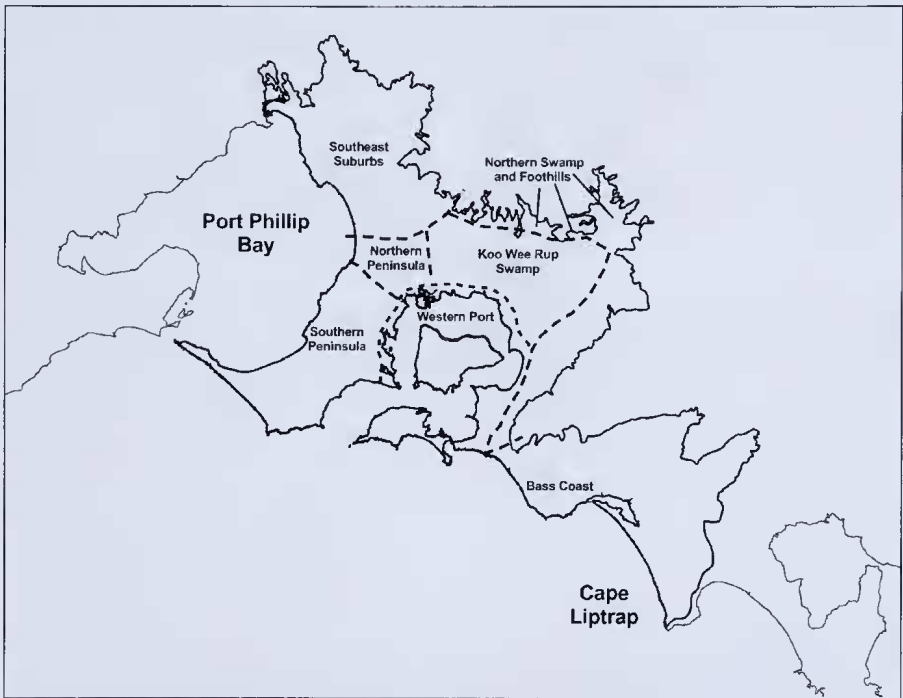


Fig. 2. Approximate location of geographic zones within the south central study area.

record) were included. Beginning 2005, additional records were compiled from road-kills, direct sightings and deliberate sign surveys by the authors, other wildlife experts, volunteers and students from Chisholm Institute of TAFE and Melbourne University. Published records of Southern Brown Bandicoots in the region were obtained from a literature search. Anecdotal observation records were solicited from the community through local councils and landcare networks and local wildlife experts.

Mapping

All of the location-specific records of Southern Brown Bandicoots in the study area were compiled and mapped using Arcview GIS 3.2 (Environmental Systems Research Institute Inc.). Location records were plotted over map layers containing extant EVCs as well as a reconstruction of the vegetation classes that were present in Victoria prior to European Settlement (DSE 2006). The reconstruction was modelled on the extant EVC information mapped at 1:100 000 with areas currently

mapped as cleared being replaced by modelled and interpreted data. These plots were used to identify EVCs that showed concordance with mapped bandicoot locations. Suitable EVCs were also identified based on information contained in published literature sources and the experience of the authors. We also incorporated a map layer identifying Victorian bioregional boundaries.

Results

Bandicoots in south central Victoria

Southern Brown Bandicoots are known to have previously occupied a range of sites across the south central region of Victoria (Fig. 3). Individuals have been recorded from as far west as Arthurs Seat on the Mornington Peninsula and as far east as the Fish Creek area in South Gippsland. However, records of the species were generally less common in either the extreme west or east of the region. The majority of available records occur throughout the northern sections of the Mornington Peninsula and coastal Western Port Bay particularly in the region between Frankston and Tooradin.

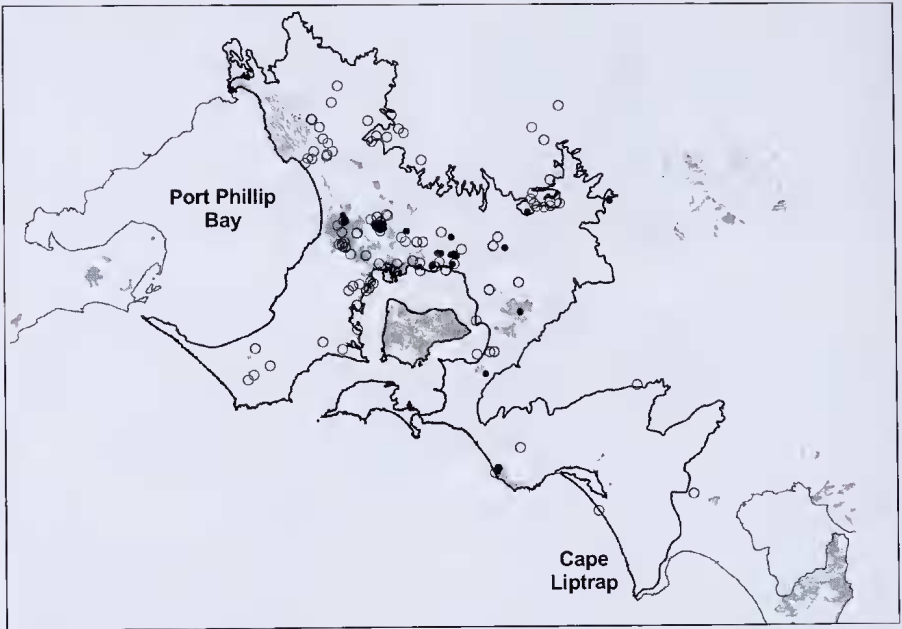


Fig. 3. Distribution of the Southern Brown Bandicoot in the south central study area. Open circles indicate records from the Atlas of Victorian Wildlife before 1991; filled circles indicate records from 1991 to 2007. Grey areas indicate historic extent of Heathy Woodland, Sand Heathland, Sand Heathland/Wet Heathland Mosaic EVCs derived from pre-1750 vegetation maps (DSE 2006).

Each of the major geographic zones within the study area is considered separately below.

South-eastern Suburbs of Melbourne

Historic records show that the Southern Brown Bandicoot was once scattered throughout the greater Melbourne region. It was known from the bayside suburbs of Melbourne and extended to the southern portions of the Mornington Peninsula. Wheelwright (1862) considered bandicoots to be common around Melbourne. Until at least the 1950s Southern Brown Bandicoots still occurred in the bayside suburbs of Sandringham, Black Rock and Beaumaris (Rayment 1954; Ward 1966). In the 1960s the species was reportedly common in some suburbs south-east of Melbourne where it occurred in ‘pockets of heathland, rough pasture and market gardens’ (Menkhorst and Secbeck 1990). Dixon (1966) remarked that it was ‘...possible to trap numbers of (southern brown) bandicoots in areas less than twenty miles (32 km) from Melbourne’. Brereton *et al.*

(2004) also noted that the species was once widespread in the suburbs east and south-east of Melbourne. In the late 1980s and early 1990s bandicoots were still believed to be ‘widespread’ at Woodlands Golf Course in Mordialloc (Brereton *et al.* 2004) and around the same time also occurred in at least two small reserves in neighbouring Dingley and Keysborough (Atlas of Victorian Wildlife, Jeff Smith pers. comm.). The species has not been reported in any of these locations for more than 15 years.

Northern Mornington Peninsula

Southern Brown Bandicoots have been reported from many sites in the Frankston area, including a range of small council reserves and golf courses (Hans Brunner pers. comm.). However, most of the Atlas of Victorian Wildlife unpubl. records in this area occur in or around several of the largest patches of indigenous vegetation remaining in the Frankston, Langwarrin, Cranbourne and Tyabb areas, partly reflecting the natural distribution of heathy

woodland vegetation communities (Fig. 3). These remnants include secure conservation reserves such as The Royal Botanic Gardens Cranbourne (RBGC), the Pines Flora and Fauna Reserve in Frankston North and the Langwarrin Flora and Fauna Reserve. The RBGC is known to still support a relatively dense population of Southern Brown Bandicoots (Coates and Wright 2003; Stava 2005; RBGC unpublished data) but populations at the other sites appear to have generally declined. Bandicoots or their signs were once common at the Pines Flora and Fauna Reserve (Armstrong *et al* 1990; Norris and Associates 1993 Kimber 1997; Taylor 1999; Hans Brunner unpubl.) but it now appears that the population at the site has declined dramatically in recent decades (Hans Brunner pers. comm. TC and DN unpubl.). A 'good' population was also known to occur in and around the nearby Langwarrin Flora and Fauna Reserve until the 1980s (Atlas of Victorian Wildlife; Andrew *et al.* 1984; Brereton *et al.* 2004) but the species has not been recorded at the site for many years (Atlas of Victorian Wildlife; Leon Costermans pers. comm.).

Southern Mornington Peninsula

Three Southern Brown Bandicoots were trapped at two sites southwest of Arthurs Seat in the early 1970s (Callanan and Gibson 1977). They were also known anecdotally from a variety of locations between Mt Martha and Greens Bush (Hans Brunner pers. comm.; Callanan and Gibson 1977). Sault (2003) noted the species had been 'fairly widespread' on the Mornington Peninsula during the later half of the 20th Century. However, documented records are actually quite uncommon in areas south-west of the Frankston-Flinders Road, including parts of the Mornington Peninsula National Park (Atlas of Victorian Wildlife; Fig. 3). No large populations have ever been identified on the southern Peninsula and no unequivocal evidence of the species has been recorded in this region since 1987, despite considerable survey effort over the last 8–10 years (Malcolm Legg pers. comm.). A single bandicoot believed to be a Southern Brown was recently reported from Point Nepean (Brett Lane pers. comm.). However, in the

absence of other recent evidence it is possible that the sighting was of a juvenile Long-nosed Bandicoot *Perameles nasuta*, a species that is known to still occur at Point Nepean and in other parts of the southern peninsula (Menkhorst and Seebeck 1995; Atlas of Victorian Wildlife; Malcolm Legg pers. comm.; TC unpublished data.).

Western Port

Andrew *et al.* (1984) considered the Southern Brown Bandicoot to be 'moderately common around the (Western Port) bay'. It has been recorded at many 'heathy' sites on the Western Port coast from Sandy Point to Grantville. The species was readily trapped at Yaringa Reserve (Tyabb) prior to 1980 (Braithwaite *et al.* 1980). Indirect evidence of the species has recently been reported from nearby Hastings (Waringine Reserve) and Crib Point (Jack's Beach), where diggings and hairs were identified in late 2006 (Malcolm Legg pers. comm.; Hans Brunner pers. comm.). There were a number of historic records from coastal regions north of Western Port including the coastal villages of Cannons Creek, Warneet and Blind Bight but the most recent records from this area came from sites to the east of Tooradin, particularly the area around the lower reaches of Cardinia Creek, Deep Creek and Bunyip River. Bandicoot scats and hairs were recently collected from near the picnic area at the Lookout tower at Tooradin Swamp (Hans Brunner and Paul Bertuch pers. comm.; TC unpublished data).

Recent evidence of the species to the east of Western Port Bay is sparse and largely anecdotal. Museum specimens were collected in this region in the 1970s and several individuals were trapped on private land near Lang Lang in the mid 1990s. Anecdotal, unconfirmed reports suggest that the species may still occur near Lang-Lang (T Westwood pers. comm.), the Gurdies and Grantville (RW unpublished records). Although Southern Brown Bandicoots were reported anecdotally to be widespread on Phillip Island early last century (Kirkwood and Johnson 2006) there are no specimens or documented records of the species from any of the islands in Western Port Bay (Phillip, French and Quail Islands).

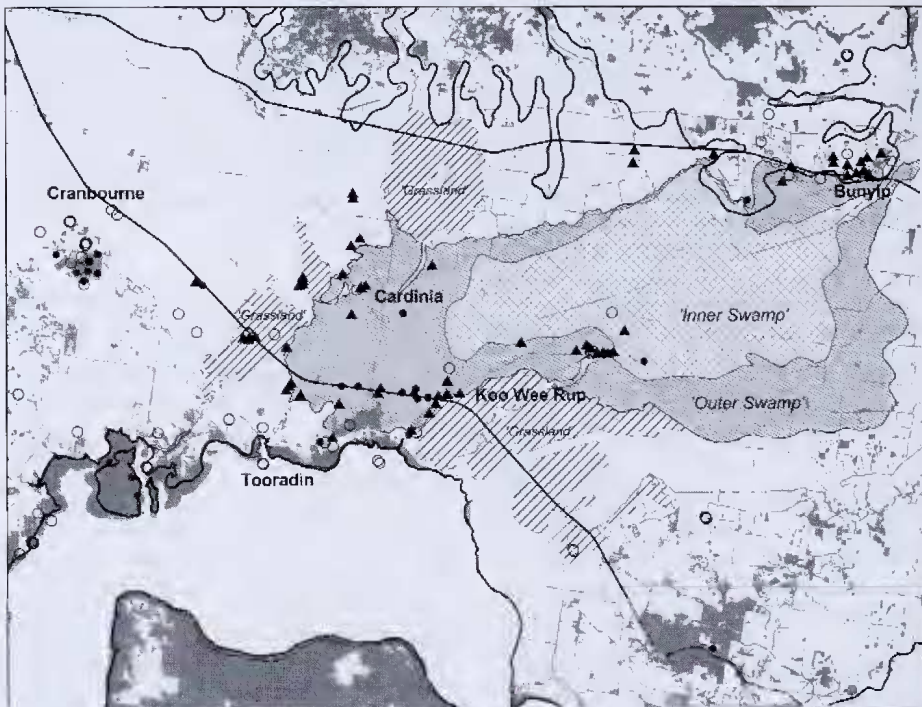


Fig. 4. Distribution of the Southern Brown Bandicoot in the Koo-Wee-Rup region. Open circles indicate historic records (1750-1990) from the Atlas of Victorian Wildlife unpubl., filled circles indicate recent records (1991-2007) from the Atlas of Victorian Wildlife unpubl. and filled triangles indicate new records collected during the present study. The figure shows the extent of remnant native vegetation (grey shading) and the historic extent of the Koo-Wee-Rup Swamp and associated grasslands from the reconstruction by Yugovic and Mitchell (2006).

Koo-Wee-Rup Swamp

Bandicoots were known from the area to the north of Western Port Bay, particularly around the (former) Koo-Wee-Rup or ‘Great’ swamp, as described by Yugovic and Mitchell (2006; Fig. 4). Prior to 1900, individuals were reported on Ballarto Road near Cardinia and on the South Gippsland Railway line north of Tooradin (Atlas of Victorian Wildlife unpubl.). During the 1970s individuals were also recorded from Tooradin and Bayles. There were a number of post-1990 records from sites near Clyde, Cardinia, Bayles and Koo-Wee-Rup (Atlas of Victorian Wildlife; DN/TC unpublished records). Many residents reported regular sightings of Southern Brown Bandicoots on private properties or utility corridors such as drains, roads and rail reserves. Property owners reported seeing Bandicoots in and around sheds and outbuildings or amongst gardens and hedges. Bandicoots were

reported from the middle reaches of the Yallock Creek (also known as Number Four Drain) near Bayles. Bandicoots were reported from, and several presumably road-killed bandicoot carcasses were recovered from roads in the region (Julie Weatherhead, Sarah Maclagan, David Nicholls unpubl.). Interestingly, there were no major patches of remnant heathy vegetation in this region, and bandicoots appeared to survive almost entirely in small remnants or narrow strips of shrubby vegetation within an otherwise agricultural matrix.

Northern swamp and foothills (Garfield to Longwarry)

Southern Brown Bandicoots were recorded from sites immediately to the north of the (former) Koo-Wee-Rup swamp. Sightings of the species from the Bunyip area date back to before 1900 (Atlas of Victorian Wildlife unpubl.). More recently, a number

of sightings have been reported between Nar Nar Goon and Drouin, but particularly from an area between Garfield, Bunyip and Longwarry. While many of these records are technically just outside the northern boundary of the study area, they are considered to be part of a larger cluster that spans the somewhat arbitrary boundary between the Gippsland Plain and the Highlands-Southern Fall Bioregion. Historically the vegetation in this region was probably a complex of lowland forest and riparian woodlands and scrubs. Many of the records appeared to be located near the road-rail corridor connecting the towns but there were also records from residential properties and riparian corridors including Ararat Creek and upper Bunyip River. The species was recorded from residential properties in both Garfield and Bunyip, and individual live animals were directly observed recently by the authors in the rail corridor two kilometres east of Bunyip (TC pers. obs.), and on land adjacent to the Longwarry Sports Oval (RW pers. obs.).

Bass Coast

Although Norris *et al.* (1979) described Southern Brown Bandicoots as 'widespread and fairly common on the coast and plains' between Wonthaggi and Corner Inlet there are only a few records of the species in the Bass Coast region. The earliest record of the species was in 1973 when an individual was trapped near Wonthaggi (Atlas of Victorian Wildlife unpubl.). Before 1750 this region probably contained a limited amount of suitable vegetation. Instead, the West Gippsland region was dominated by heavier soils that mainly supported Grassy Woodlands, Swamp Scrub, Damp Heathy Woodlands and Herb-rich Woodlands (DSE 2006). Records were restricted largely to the narrow band of Sand-Heathland/Damp Heathland that existed near the coast between Wonthaggi and Cape Paterson, particularly in what is now the Wonthaggi Heathlands Conservation Reserve. Small numbers of individuals have been trapped at the Wonthaggi Heathlands in recent years, confirming that the species still occurs there (P Homan 2008). However, low trapping rates within the reserve suggest the population there

may be small. Outside of this discrete area of heathland, records were sparse with few, widely spaced records. These records include a fresh bandicoot carcass positively identified as a Southern Brown found in coastal scrub between Tarwin Lower and Walkerville in 2005 (I. Gunn pers. comm.). A southern brown bandicoot was collected from this region in 1977, but it is possible that some anecdotal records may in fact be of Long-nosed bandicoots, a species known to occur at nearby Cape Liptrap and Walkerville (Braithwaite 1978; Menkhorst and Seebeck 1995b). Following reports of 'bandicoot' sightings around Venus Bay, targeted surveys were conducted during 2006 but these did not record any direct evidence of either Long-nosed or Southern Brown Bandicoots (Mae Adams pers. comm.).

Discussion

Southern Brown Bandicoots appear to persist at a number of locations throughout the South Central region of Victoria. While there is evidence that the range of the species may have contracted in recent decades, populations still appear to be scattered across a number of sites between Frankston and Wonthaggi. Throughout this region the historic distribution of the species was determined largely by the distribution of sandy soils that supported dense heathy vegetation, particularly Heathy Woodland and Sand Heathland EVCs. This type of vegetation formed on deep, nutrient poor, siliceous podsoils characteristic of early Pleistocene aeolian dune systems. Such soils are common throughout the extensive sand sheets that run south-east from the Frankston-Carrum area of Port Phillip Bay to Tyabb and Tooradin on the Western Port coast (Rosengren 1984). The highest density of bandicoot records in the study area occur within this region, particularly at sites such as the Royal Botanic Gardens Cranbourne and Pines Flora and Fauna Reserve, where relatively large patches of the original dense heathy vegetation remain. The sand sheets continue to the east and support discrete patches of Sand Heathland and Heathy Woodland both on French Island and in the region between Lang-Lang and the Gurdies on the eastern side of Western Port Bay.

Elsewhere in the study area this vegetation was probably less common. In the southern parts of the Mornington Peninsula, areas of aeolian dunefield occur at Sandy Point and in a broad area between Rosebud and Picnic Point (SGAP 1991; Sault 2003; Fig. 3). Bandicoots were previously known from these areas but Heathy Woodlands or similar dense scrubby vegetation appear to have been relatively uncommon on the Mornington Peninsula (DSE 2006). Instead, the vegetation of the Peninsula was probably dominated by more open woodland communities such as Damp Sands Herb-rich Woodlands (DSE 2006) that may be less likely to support dense populations of bandicoots. The lack of extensive areas of suitable vegetation may account for the relatively small number of records from this region. Similarly, vegetation on the Bass Coast may also have been dominated by more open woodlands with dense heathy communities largely restricted to a relatively small area on Cape Patterson, and the Southern Brown Bandicoot may have never been widespread in the region. Throughout many of these regions the species may have occupied dense thickets of swampy riparian scrub that formed in drainage lines.

Heathy vegetation like that occupied by Southern Brown Bandicoots elsewhere in the state was probably also uncommon in the area north of Western Port Bay. Instead, the heavier soils of the former Koo-Wee-Rup swamp originally supported extensive tracts of inundated Swamp Scrub interspersed by Swampy Riparian Scrubs, Woodlands and Grass-lands or Grassy wetlands (DSE 2006; Yugovic and Mitchell 2006). On the northern edge of the swamp in the foothills, the original vegetation was probably a mosaic of Swampy Riparian Scrub, Wet Heath-land and Damp (Clay) Heathland (DSE 2006). However, despite the lack of Heathy Woodland vegetation, bandicoots have been recorded at many sites throughout this region. The majority of records in the area occur on the margins of the outer swamp or where sand ridges or riparian corridors occur within the swamp. Bandicoots were recorded within areas believed to have formerly supported grasslands, particularly the Tooradin Grassland described by Yugovic and Mitchell (2006).

To our knowledge Southern Brown Bandicoots have rarely been recorded in grassland habitats elsewhere in south-eastern Australia.

Bandicoots were reported from a range of sites throughout the Koo-Wee-Rup area, including many now dominated by exotic pasture, gardens, Box-thorn hedges, Blackberry or Gorse thickets. Bandicoots also occurred around woodpiles, car bodies, sheds and other low structures that probably provided suitable refuge. Individuals were known to scavenge for anthropogenic food around houses, chicken coops, rabbit hutches or livestock feed bins, and at some properties were apparently quite tolerant of humans. Individuals were also recorded from a number of locations in a narrow band stretching from Nar Nar Goon to Drouin. Locations included residential areas, recreation and farming land and a number of records along the road-rail corridor between Garfield and Longwarry.

Linear corridors such as drains, roads and rail reserves appeared to be a feature of bandicoot locations throughout the region north of Western Port Bay. Many of the sites where Southern Brown Bandicoots were recorded were near railway lines or drainage lines that contained some dense groundcover. Road-killed bandicoots were also recovered or reported where drains or other corridors intersected with roads (D Nicholls pers. obs.). There were few sizable patches of indigenous vegetation remaining in this part of the study area and bandicoots appeared to be utilizing the cover available in narrow strips of dense vegetation within a predominantly agricultural matrix.

The existence of the Koo-Wee-Rup population, in the absence of substantial patches of remnant native vegetation, is unusual. A number of authors have previously identified the conversion of high proportions of indigenous vegetation to agricultural land as a likely cause of population decline in the species (Ashby *et al.* 1990; Bennett 1990; Friend 1990; Menkhorst and Seebeck 1995). Paull (1995) found that the distribution of the species in South Australia was closely related to the distribution of remnant native vegetation, most of which was secured in public reserves. Brown (2004) did not identify any 'import-

tant' populations in Victoria or New South Wales that existed away from such reserves. Bennett (1990) found that Southern Brown Bandicoots in south-west Victoria were predominantly confined to larger forest patches. Rees and Paull (2000) also concluded that the species made only limited use of linear reserves in agricultural landscapes in the Portland region. They found no evidence that the species either persisted in such locations or used them to disperse between neighbouring patches of remnant vegetation. The rarity of bandicoots at such sites has been attributed in part to high predation pressure, particularly from introduced foxes (Rees and Paull 2000). However, a number of other key threatening processes may also disproportionately affect populations in linear reserves. These include road mortality, weed invasion, inappropriate fire regimes and stochastic effects related to small effective population size. How bandicoots manage to persist under such conditions remains somewhat mysterious. Unfortunately reports from some local residents suggest that these populations may have declined in recent decades.

There is also indication of a decline in known Southern Brown Bandicoot populations in several dedicated conservation reserves in the south central region within the past two decades. Brereton *et al.* (2004) noted that a 'good' population of Southern Brown Bandicoots occurred at Langwarrin Flora and Fauna Reserve (and adjacent land) in the late 1980s. The species was also thought to be relatively common on publicly reserved land near Tyabb (Yaringa) during the 1970s (Braithwaite *et al.* 1980). The species has not been definitively recorded at either site since 1990 despite some targeted efforts in recent years (Leon Costermans pers. comm.; Fauna Survey Group Victoria unpublished data; Darren Quinn pers. comm.; TC unpublished data.; Darren Southwell pers. comm.). The population at The Pines was also once thought to be relatively dense (Taylor 1999; Hans Brunner pers. comm.) with multiple individuals readily captured or otherwise detected during the 1980s and 90s. Although the species was recently confirmed as still present at The Pines, there was clear indica-

tion that it no longer occurred at sites within the reserve where it had been recorded during earlier surveys (Norris and Associates 1993, Kimber 1997; Hans Brunner pers. comm.; TC and DN unpublished data). The population remaining in the reserve may now be critically small and its isolation from other populations in the region makes it highly vulnerable to extinction. Elsewhere on the Mornington Peninsula the species has not been definitively recorded in conservation reserves since at least 1987.

Conclusions

The results of the current study give rise to concern about the remaining populations of Southern Brown Bandicoots in the south central region of Victoria. The region generally supports only small, isolated populations, many of which face potentially high levels of threat. We could identify only one moderately dense, stable population of Southern Brown Bandicoots in a secure nature reserve in the entire region. Populations in most other reserves now appear to be very small and some have disappeared in recent decades. The size of two known extant populations at The Pines Flora and Fauna Reserve and Wonthaggi Heathlands Reserve are unclear but the low level of reporting and low trap and sign detection success gives rise to concern they may contain only a small number of individuals. While both populations may be small, 'The Pines' population appears to be particularly vulnerable and may have declined substantially in recent decades. The area around The Pines has urbanized rapidly in the last 10 years and the population in the reserve probably faces increasing threats from a range of factors linked to urbanization. Many of the threats facing the population appear difficult to manage because of the proximity of residences and the restrictions this places on appropriate management actions. Unfortunately, the history of similar populations elsewhere in the region suggests that without effective management the population will almost inevitably become extinct.

While Southern Brown Bandicoots appear to have a restricted distribution throughout much of South Central Victoria, they were surprisingly wide-

spread in the Koo-Wee-Rup region. Although not exhaustive, our records suggest four main clusters of records occur mainly on unsecured land near Koo-Wee-Rup, Bayles, Cardinia and Garfield-Longwarry. Publicly reserved habitat is rare in this region, and the species appears to survive in a highly modified agricultural landscape where it exploits a range of anthropogenic resources. Unfortunately, however, the populations in this area are vulnerable because most of the habitat occupied by bandicoots is on private or utility land and subject to high levels of a number of threatening processes. Experience elsewhere in the region does not give great confidence that this type of habitat is capable of sustaining bandicoot populations in the medium to long term unless coordinated actions are implemented throughout the region to manage the threats. Indeed, there is some anecdotal evidence that at least some of these populations have declined in recent decades. There is now a clear need to determine the size and extent of these populations and to develop management responses that operate effectively across multiple land tenures.

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